



What will AI Ophthalmology v2.0 look like?

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Artificial intelligence: from ‘gee whiz’ to ‘wow’

It is fair to say that the field of artificial intelligence (AI) has moved from the ‘gee whiz’ phase to the ‘wow’ phase. In the ‘gee whiz’ phase, a computer could be programmed to play checkers as well as a human player. Jumping ahead to the ‘wow’ phase, convoluted neural networks (CNNs) facilitate the detection of clinically significant levels of glaucomatous optic neuropathy, retinopathy of prematurity, and diabetic retinopathy with precision that rivals and even exceeds that of skilled clinicians. CNNs are computer algorithms that are organized in ways that allow for layered processing of data with a hierarchical architecture that mimics the cerebral visual cortex. The FDA has approved two AI algorithms — IDx¹ and EyeArt² — for their ability to detect referable diabetic retinopathy as well as a reading center manned by experts using robust clinical standards. The new journal, *Modeling and Artificial Intelligence in Ophthalmology*, will chronicle AI Ophthalmology version 2.0. What will AI Ophthalmology v2.0 look like?

Clinical care

Programming languages with commands to perform the forward- and back-propagation steps that optimize the computer learning process are used to construct CNNs that power AI algorithms in medicine. CNNs are well suited to autonomously analyze ophthalmic images, opening the door to numerous opportunities to advance our field. In AI Ophthalmology version 2.0, we can expect AI to expand beyond diagnosing disease to identifying idealized therapeutic approaches to treat and forecast ophthalmic disease course. Furthermore, AI will be used in ophthalmology research to effectively discover metabolite and genetic profiles that differentiate patients with common complex eye diseases like age-related macular degeneration and glaucoma from controls. An interesting fusion between mathematical modeling and AI seems possible with the advent of optical coherence

tomography angiography (OCTA). OCTA demonstrates unparalleled ability to resolve the various plexiform vascular beds in the retina and generate quantitative data on vessel density, vascular tortuosity, foveal avascular zone area,³ etc., enabling exciting possibilities of combined mathematical modeling and AI in understanding ophthalmic diseases with a retinal vascular component.

Teaching

As AI Ophthalmology version 2.0 evolves, there will be a need to create continuing medical education programs for trainees and practicing ophthalmologists to educate and update them about the field. It will also be worthwhile to reverse engineer the computer learning process to make practitioners better observers of clinical material and researchers better able to decipher the clues hidden in their complex datasets. We often hear the phrase, “a picture is worth a thousand words”. The ability to be a keen observer of ophthalmic images is what makes ophthalmologists well suited to describe the retinal manifestations of systemic disease. AI has extended this power of observation to include chronological age prediction, ascertainment of sex, prediction of smoking status, and estimation of actual blood pressure levels.⁴ Learning how CNNs extend these powers of observation is certainly worthwhile. Interestingly, this process has already begun. Lessons learned thus far include that, among imaging modalities, OCT volume scans are superior to cross-sectional OCTs and fundus photos for age and sex prediction.⁵ Furthermore, fundus photos with both the optic nerve and macula are needed for sex prediction. Finally, the ability to make these predictions does depend on the existence of ophthalmic pathology and is also age dependent.

Health equity

AI offers a great opportunity to level the playing field in terms of providing access to care to all people in all corners of the world. The challenge in AI is that training algorithms typically requires large amounts of data and it is important that such datasets are representative of the diverse populations where they will be implemented.⁶ Furthermore, there is a need to create algorithms that work for images captured on a variety of platforms, including cell phones, which are readily available. Another trend that is already happening is the use of machine-to-machine learning to train algorithms that predict OCT level retinal biomarker quantitative data from fundus photographs.⁷ The ability to convert a fundus camera into an instrument that could also extract OCT level data will be welcome in areas where OCT technology is not available or not affordable. Also, there is a need for cloud-based computing like auto machine learning to make AI available

to interested physicians so that they can tailor algorithms that have utility in their own practice.⁸ Finally, since AI algorithms can function as well as reading centers,¹ then there may be a reduced need for such centers in randomized clinical trials (RCTs) for conditions like rapidly progressive open-angle glaucoma, dry age-related macular degeneration, and anterior ischemic optic neuropathy. The reduced costs associated with supplanting reading centers with AI-based approaches could shunt resources devoted to the discovery of new neuroprotective agents for these conditions.

Challenges

There are several burning questions that extend beyond the ‘wow factor’ as we enter AI Ophthalmology v2.0:

1. Will there be a RCT showing that implementation of an AI algorithm results in preservation or improvement in vision?
2. How do we engage the next generation (and the current generation for that matter) of ophthalmologists to embrace AI in their practice given the inevitable penetration of this discipline into every aspect of medicine in general and ophthalmology in particular?
3. Will AI algorithms be able to ‘multitask’? Currently, algorithms are designed to detect one outcome but will be totally agnostic to other coexistent but clinically important outcomes.
4. How will AI algorithms be maintained such that they robustly and faithfully perform their appointed tasks over time?

Conclusion

Ophthalmic researchers have been on the forefront of the AI revolution. The future for AI in ophthalmology is bright when one considers the merger of this field with disciplines like genomics, the microbiome, and integrated longitudinal medical records that incorporate systemic conditions. AI has the capability to improve care, make physicians better clinical observers and allow them to make more cost-effective medical decisions in the allocation of care. There is also the possibility that AI Ophthalmology v2.0 will work to assist our colleagues in the management of other neurodegenerative and neuropsychiatric diseases such as Alzheimer’s disease and schizophrenia, as the retina is an accessible aspect of the central nervous system.

Declarations

Competing interests

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